APPENDIX C1

LIVE LOAD EFFECTS ON A THREE-SPAN CONTINUOUS BRIDGE: ANALYSIS CHECK AND EFFECT OF TAPER AND HAUNCH

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PURPOSE

The purpose of this analysis was to verify the slope-deflection model used in the FORTRAN program which employs constant modulus of elasticity (E) and moment of inertia (I), to determine load effects; shear and moment and to consider the effect of taper and haunch on the load effects compared to uniform cross sectional elements.

PRODECURE

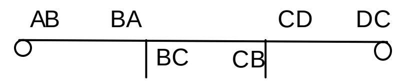
A 3-span continuous bridge with all spans 50 feet was used for the study. Load effects were determined at support centerlines and at 5 and 15 feet away as well as at mid-spans. Three loadings were used for comparison; A 1 kip moving point load, the AASHTO HS20-44 design vehicle (both spacings were 14 ft) (Figure C1.1), and the Permit 4 vehicle (Figure C2.8 in Appendix C2). The vehicle axle weights and spacings are shown in Appendix C2. Two programs were used for analysis; FORTRAN and SAP2000. The results from FORTRAN were first compared to a prismatic model in SAP2000.

The FORTRAN results were modified with sign changes and mirror images in order to reflect the same sign convention used in SAP2000 and to account for the vehicle being "driven" over the model in only one direction.

To explore the effects of taper and haunch, a search was performed of bridges database which produces two histograms. The first one was for bridges that have a tapered web (i.e., change in web thickness, b), and a second for bridges with a haunched web (i.e., change in web height, h). Taper/b = 0.00 and Haunch/h = 0.00 was represented by the prismaticmodel. Tapered and haunched section changes begin at the span quarter points. A tapered section was modeled in SAP2000 to represent the actual web changes in the McKenzie River Bridge which has a Taper/b = 0.54. To consider the possible range of ratios, a second bridge (No. 07832) that has similar span lengths with a Taper/b = 0.93 was modeled. Two haunched sections were modeled in SAP2000 for a Haunch/h = 0.51 (bridge No. 07519) and the Mary's River Bridge with Haunch/h = 0.86.

RESULTS

For quick reference, a summary of the percent change from prismatic to various haunch and taper ratios taken at key points was tabulated in Table AM1-1. Plots follow comparing the percent difference in load effects of all vehicles between the prismatic section and the tapered or haunched sections (Figures AM1-1 to AM1-4). The portion displayed was for the portion of the envelope that was the maximum at that position. It should be noted that a positive (+) percent change indicates that the value decreased from that of the prismatic section and a negative (-) percent change indicates an increase. Following each percent difference plot are the respective moment or shear envelopes for each loading.



Ratio	Loading	Percent Change																	
		AB		Mid-span		BA		BC		Mid-span		CB		CD		Mid-span		DC	
		V	M	V	M	V	M	V	M	V	M	V	M	V	M	V	M	V	M
Taper/b = 0.54	1 kip	0.00%	0.00%	-2.03%	3.04%	0.00%	-11.89%	0.00%	-11.89%	0.00%	3.56%	0.00%	-11.89%	0.00%	-11.89%	-2.03%	3.04%	0.00%	0.00%
	HS20-44	0.68%	0.00%	-2.20%	3.54%	-0.64%	-11.43%	-0.09%	-11.43%	0.22%	4.19%	-0.09%	-11.43%	-0.64%	-11.43%	-2.20%	3.54%	0.68%	0.00%
	Permit 4	1.01%	0.00%	-3.05%	3.94%	-1.14%	-10.28%	-0.95%	-10.28%	-3.65%	4.65%	-0.95%	-10.28%	-1.14%	-10.28%	-3.05%	3.94%	1.01%	0.00%
Taper/b = 0.93	1 kip	0.00%	0.00%	-3.19%	4.77%	0.00%	-18.70%	0.00%	-18.70%	0.00%	5.45%	0.00%	-18.70%	0.00%	-18.70%	-3.19%	4.77%	0.00%	0.00%
	HS20-44	1.07%	0.00%	-3.48%	5.54%	-0.99%	-17.87%	-0.14%	-17.87%	0.32%	6.37%	-0.14%	-17.87%	-0.99%	-17.87%	-3.48%	5.54%	1.07%	0.00%
	Permit 4	1.59%	0.00%	-4.72%	6.18%	-1.76%	-15.98%	-1.50%	-15.98%	-5.77%	7.07%	-1.50%	-15.98%	-1.76%	-15.98%	-4.72%	6.18%	1.59%	0.00%
Haunch/h = 0.51	1 kip	0.00%	0.00%	-5.74%	8.59%	0.00%	-33.05%	0.00%	-33.05%	0.00%	10.30%	0.00%	-33.05%	0.00%	-33.05%	-5.74%	8.59%	0.00%	0.00%
	HS20-44	1.74%	0.00%	-5.87%	9.21%	-1.52%	-29.04%	-0.03%	-29.04%	-0.06%	10.92%	-0.03%	-29.04%	-1.52%	-29.04%	-5.87%	9.21%	1.74%	0.00%
	Permit 4	6.35%	0.00%	-2.70%	14.46%	1.80%	-18.99%	2.74%	-18.99%	-3.89%	16.71%	2.74%	-18.99%	1.80%	-18.99%	-2.70%	14.46%	6.35%	0.00%
Haunch/h = 0.86	1 kip	0.00%	0.00%	-7.12%	10.65%	0.00%	-41.17%	0.00%	-41.17%	0.00%	13.54%	0.00%	-41.17%	0.00%	-41.17%	-7.12%	10.65%	0.00%	0.00%
	HS20-44	2.06%	0.00%	-7.10%	11.13%	-1.87%	-35.41%	-0.02%	-35.41%	-0.13%	14.24%	-0.02%	-35.41%	-1.87%	-35.41%	-7.10%	11.13%	2.06%	0.00%
	Permit 4	6.95%	0.00%	-4.52%	16.40%	1.12%	-24.80%	2.35%	-24.80%	-6.14%	20.02%	2.35%	-24.80%	1.12%	-24.80%	-4.52%	16.40%	6.95%	0.00%

Table C1.1: Summary of percent change at key points dependent on loading and haunch or taper ratios.

OBSERVATIONS

Linear Model Check

Moving the vehicle incrementally, especially the large Permit 4 vehicle, in only one direction in the linear model (produced in FORTRAN) affects the shear envelope results due to asymmetry of the loading.

For All Loadings

Additional stiffness in the thickened section attracts more moment to the supports while reducing the positive moment near mid-spans.

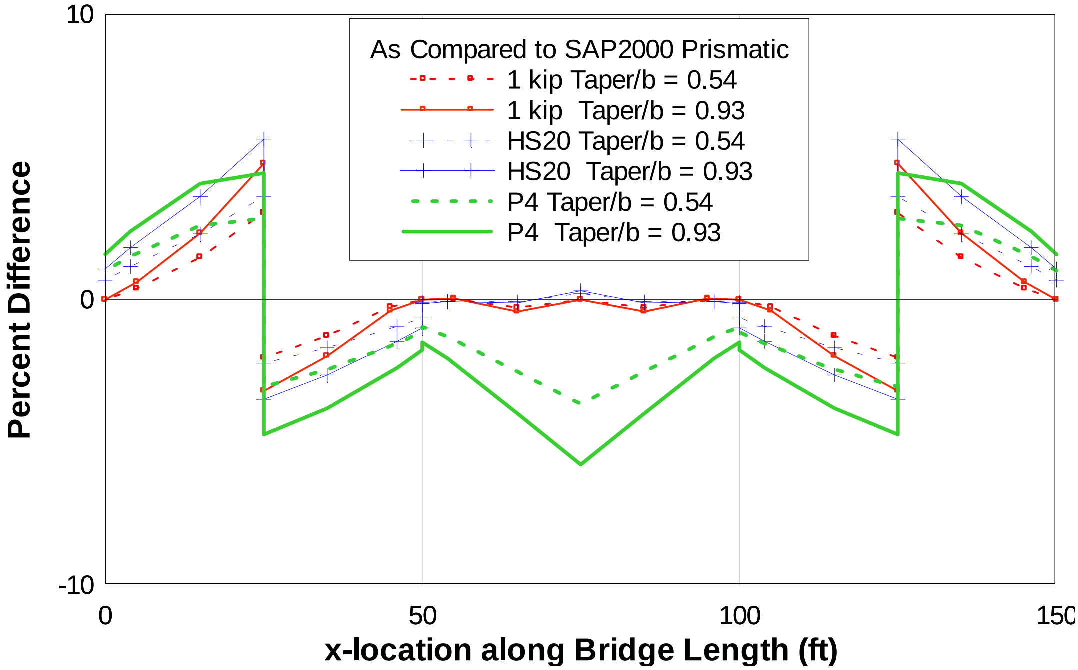


Figure C1.1: Percent change in shear for tapered sections of a three (50 ft)-span continuous bridge.

Taper

Tapered sections had a consistent percent change increase in shear at the supports. The percent change in shear for all loading types and taper ratios was less than 2% at the supports and less than 6% at mid-spans. The positive moment near mid-spans decreases by less than 10%. The negative moment increases by approximately 12% at the supports for a taper ratio of 0.54 and 18% for a ratio of 0.93.

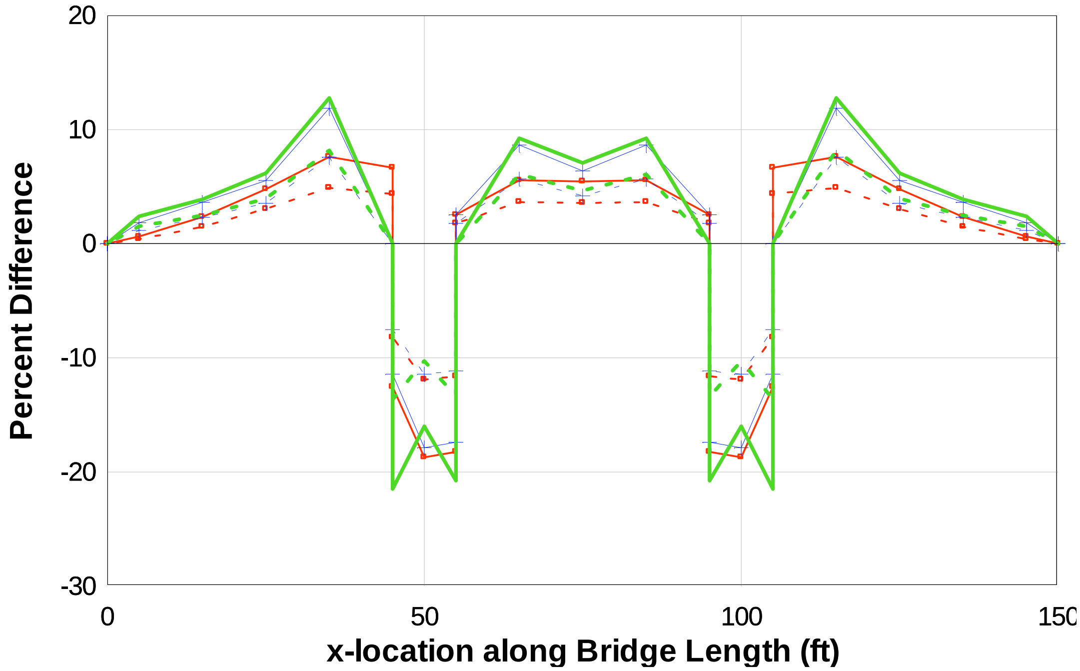


Figure C1.2: Percent change in moment for tapered sections of a three (50 ft)-span continuous bridge.

Haunch

Haunched sections have shear increases and decreases of less than 3% at interior supports. The simply supported ends decrease 0-7% depending on the loading, but appear unaffected by the size of the haunch ratio. However, the change in moment does depend on the loading and haunch ratio. The positive moment decreases 10-20% at mid-spans, while the negative moment increases 20-40% at the interior supports.

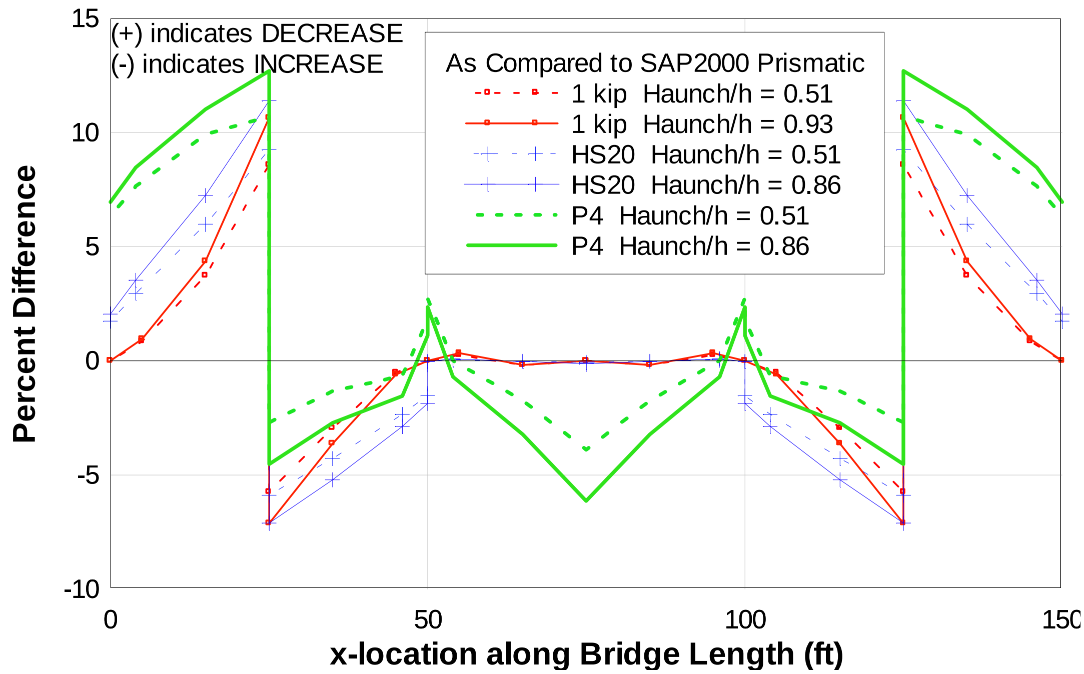


Figure C1.3: Percent change in shear for haunched sections of a three (50 ft)-span continuous bridge.

CONCLUSIONS

Model Check

The linear FORTRAN model appears to be predict moments and shears correctly when compared to the prismaticSAP2000 model. It should be noted however, that for completeness, the vehicles must be moved incrementally across the bridge model in both directions when calculating the load effects.

Taper

It also appears that a horizontal taper had a linear effect on the shear from varying vehicles since the shear changes consistently regardless of taper ratio or loading. The change in shear was minimal at the supports (less than 2%) and can be ignored. Though the positive moment decreases up to 10% near mid-spans, the negative moment increases from 12-18% depending on the ratio, and should be considered since this amount will likely impact the design.

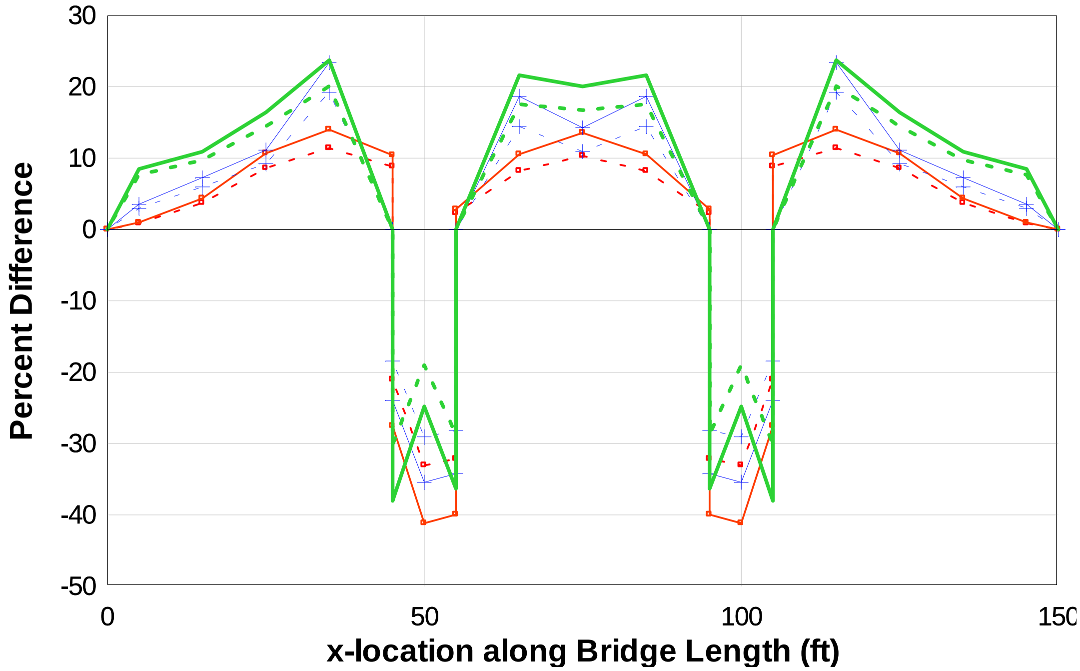


Figure C1.4: Percent change in moment for haunched sections of a three (50 ft)-span continuous bridge.

Haunch

Shear in a haunched section was affected most at mid-spans. The shear decreases at the end supports and increases by less than 3% at the interior supports. Therefore, since design was usually controlled by shear at the supports, the change can be ignored. Since the positive moments near mid-span decrease they too can be ignored. However, the negative moment requires special attention with increases between 20 and 40% depending on the loading and the haunch ratio.